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Report No. UMTA-MA-06-0048-81-1

SYSTEMS OPERATION STUDIES FOR AUTOMATED GUIDEWAY TRANSIT SYSTEMS

FEEDER SYSTEMS MODEL FUNCTIONAL SPECIFICATION

GM Transportation Systems Division
General Motors Technical Center
Warren, MI 48090

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JUNE 1981
FINAL REPORT

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URBAN MASS TRANSPORTATION ADMINISTRATION
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16. Abstract

Functional requirements are specified for the AGT-SOS Feeder Systems Model (FSM). The primary function of this model is to assign zone-to-zone transit patronage demand to Automated Guideway Transit (AGT) station pairs. The assignment is based on the trip time ratio between using an alternate mode of transportation and the AGT system. The model output may be used as part of the data to compare different AGT systems operating in the same demand environment. Because of its generic nature, the model is recommended for representative AGT deployments' comparison only.

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16. Abstract

In order to examine specific Automated Guideway Transit (AGT) development and concepts, and to build a better knowledge base for future decision-making, the Urban Mass Transportation Administration (UMTA), has undertaken a new program of studies and technology investigations known as the UMTA Automated Guideway Transit Technology (AGTT) program. The objectives of one segment of the AGTT program, the Systems Operations Studies (SOS), are to: 1) develop models for the analysis of system operations; 2) evaluate performance and cost; and 3) establish guidelines for the design and operation of AGT systems.

This document specifies the functional requirements for the AGT-SOS Feeder Systems Model (FSM), the type of hardware required, and the modeling techniques employed by the FSM. The objective of the FSM is to map the zone-to-zone transit patronage demand onto AGT station pairs and to generate feeder system performance data. The output of this model can be used in conjunction with AGT data in order to provide normalized comparisons between different AGT systems operating in the same demand environment with both conventional feeder service/AGT operation and dual mode feeder/AGT operation. Because of its generic nature, the model is recommended for representative AGT deployments' comparison only.

The current SOS for AGT Systems reports in this group are: System Availability Model User's Manual (UMTA-MA-06-0048-81-2); Availability Model Functional Specification (UMTA-MA-06-0048-81-3); System Availability Model Programmer's Manual (UMTA-MA-06-0048-81-4); and Detailed Station Model Functional Specification (UMTA-MA-06-0048-81-5

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PREFACE

In order to examine specific Automated Guideway Transit (AGT) developments and concepts--and to built a better knowledge base for future decision-making--the Urban Mass Transportation Administration (UMTA) has undertaken a new program of studies and technology investigations called the UMTA Automated Guideway Transit Technology (AGTT) program. The objectives of one segment of the AGTT program, the Systems Operations Studies (SOS), are to develop models for the analysis of system operations, to evaluate performance and cost, and to establish guidelines for the design and operation of AGT systems. A team headed by GM Transportation Systems Division GM TSD) has been awarded a contract by the Transportation Systems Center to pursue these objectives. The Technical Monitor for the project at TSC was Arthur Priver, who was assisted by Li Shin Yuan and Thomas Dooley.

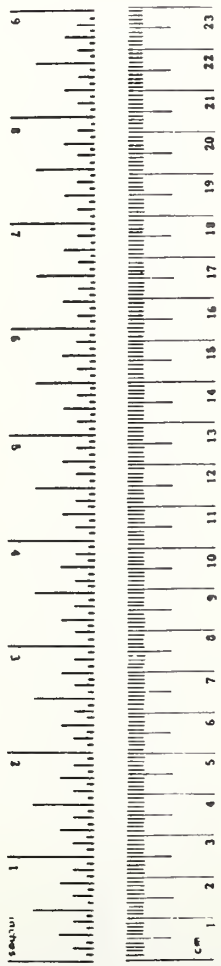
The Feeder System Model (FSM) will be used to assign station-to-station travel demands. This functional specification identifies the functions performed, the types of hardware required, and the modeling techniques employed by the FSM.

The work reported here was performed under the direction of the SOS Program Manager, James F. Thompson, at GM TSD. The research, preparation, and completion of the report was performed by Terry M. Linden.

METRIC CONVERSION FACTORS

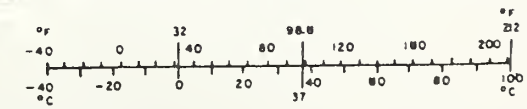
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

This document specifies the functional requirements for the AGT-SOS Feeder Systems Model (FSM).

1.1 Objective

The objective of the Feeder Systems Model (FSM) is to map the zone-to-zone transit patronage demand onto Automated Guideway Transit (AGT) station pairs and to generate feeder system performance data. The output of this model can be used in conjunction with AGT data in order to provide normalized comparisons between different AGT systems operating in the same demand environment with both conventional feeder service/AGT operation and dual mode feeder/AGT operation. The feeder systems operations are modeled analytically and the model is intended for generic use only.

1.2 Scope

The FSM will model the performance of both the fixed route service operating on grid networks and the demand responsive service. In the model it will be assumed that the feeder system consists of local mass transit mode (Feeder), the private automobile mode (Auto) and the pedestrian mode (Walk).

The FSM will model the effect of the following system characteristics, as appropriate, for each of the modes:

- Average speed
- Route spacing
- Headway
- Fleet size
- Equipment reliability
- Wait time

The FSM input demand data resolution will be at the zone level and will be considered as a point source/point sink located at the zone centroid. Uniform feeder system performance will be assumed over user specified service regions, consisting of zones, and time intervals.

The FSM output will consist of a series of OD station pair demand matrices which define demand over the entire demand interval, a table of access and egress times for each station, the number of trips not served by the AGT system, the feeder fleet size, feeder vehicle mileage, feeder vehicle operating hours, and a series of station egress tables over the entire demand interval.

2.0 REQUIREMENTS

2.1 Functions

The fundamental charter of the FSM is to map zone/zone, origin/destination (OD) demand data onto an AGT. This mapping includes generation of:

- Station/station demand rate data
- Station access and egress performance data
- Feeder system utilization data

To assure a flexible model, the FSM will contain well-bounded modules for each of the major steps in the following functional processing description:

Step 1) Find the nearest N stations for each zone in the system.

Step 2) Select from the N station subset from Step 1, an OD station pair such that the performance measure for the zone/zone trip is optimized. Associate the zone pair with the station pair. If the performance obtained by making the OD zone pair trip by feeder system is greater by a factor of K than that obtained by using the automated guideway for one segment of the trip, then count the trip as unserviceable by the AGT system.

Step 3) For those trips which are serviceable by the AGT system, divert an additional amount of demand to "feeder only" service by a comparison of the "feeder/AGT time" to the sum of that and the "feeder only" time. After this diversion, associate the zone pair with the selected OD station pair. Then, for each time interval, generate OD station demand by summing the zone pair demands associated with each station pair. Similarly, generate the station egress demand for each station.

Step 4) Perform a submodal split on demand for each zone/station demand pair (i.e., allocate the demand to local modes of transportation).

Step 5) Calculate the average on-vehicle and off-vehicle access and egress times for each of the stations.

Step 6) Calculate the total system utilization measures, including total vehicle mileage, vehicle operating hours, and fleet size.

2.1.1 Preliminary Zone/Station Association Function Module

This function module is used for major processing Step 1. Given a zone, it will associate a set of N stations with that zone. The association will be made on the basis of the X, Y distance (as opposed to straight line distance) between the zone centroid and the station.

Mapping of an OD zone demand onto a network involves determination of zone/station assignments which yield the highest performance path running from origin zone to origin station to destination station to destination zone for each OD zone pair. This function will select a subset of stations which have a serious chance of being on the highest performance paths for each zone.

Inputs to the Preliminary Zone/Station Association module will include zone centroid locations, station locations, and the user variable specifying the number of stations to be associated with each zone. The output will be the association of N stations with each zone and the X, Y zone centroid/station location distance for each zone/station association.

2.1.2 Final Zone/Station Association Function Module

This function module will be used for major processing Step 2. Given an OD zone pair, a set of N associated stations for both the origin and destination zones, a performance measure for each of the 2N zone/station pairs, and a performance measure for each OD station pair, this function will select the OD station pair which maximizes the performance measure for each OD zone pair trip. This involves comparison of the N^2 combinations of OD station pairs for each zone pair. Selection of stations will be performed for every zone "pair" because it is possible that trips with common zone origins and different zone destinations will pass through different origin stations.

2.1.3 OD Station Demand Generation Function Module

This function module is used for major processing Step 3. Given OD zone pair data, zone pair/station pair associations, and zone centroid locations, this function screens out trips not best served by the AGT system and sums OD zone demand data to generate OD station data. Several zones will contribute to demand for each OD station pair, but the network demand data specifies demand as seen at the station. Therefore, the demand for the several zones will be summed so as to define a single demand as seen at the station for each OD station pair for each time interval. The OD station demand will be used to generate station egress demand data for each station for each time interval. The aforementioned unserviceable demands will be identified and counted.

2.1.4 Submodal Split

This function module is used for major processing Step 4. Total trip demand for the zone/station pair will be allocated to 3 submodes:

- Auto (Private automobile)
- Feeder (Mass transit fixed route or demand responsive service)
- Walk

Walk mode demand for a zone/station pair will be modeled as a function of:

- Total trip demand for the zone/station pair
- Walk factor: a measure of how receptive the demand is to walking
- Zone area
- Walk area: the area around AGT stations which is sufficiently convenient to warrant consideration of walking
- Walk proportioning factor: the proportion of walk area which is applicable for the particular zone when the walk area is not totally within the zone

Except for AM peak period egress and PM peak period access, after walk demand has been subtracted from total demand, the remaining demand for a zone/station pair will be modeled as a function of:

- Feeder factor: a measure of how receptive the demand is to feeder use
- Maximum acceptable walk distance (fixed route only): the maximum acceptable walk distance to access a fixed route
- Effective route spacing (fixed route only)
- Maximum tolerable availability: headway for fixed route systems; wait time for demand responsive systems
- Actual availability

AM peak period egress from and PM peak period access to the AGT station will be mdeled as work oriented trips for which there is no auto available. Hence the feeder demand will be the non-walk demand (i.e., the remaining zone/station demand after the walk demand has been subtracted).

Auto mode demand will be modeled as that part of total demand which neither walks nor uses the feeder system.

The aforementioned submodal split parameters will be defined, as appropriate, for each service interval, for each service region, and for access and egress modes. The model will utilize default parameters which can be overridden by the user. For example, sets of default parameters will be provided for three generic service intervals: AM and PM peak, mid-day, and evening.

2.1.5 Performance Modeling Function

This function is used for major processing Step 5 and will model feeder system performance as a function of:

- Feeder service type
  - Fixed route grid, passengers transfer at stations
  - Fixed route grid, dual mode
  - Demand responsive, passengers transfer at stations
  - Demand responsive, dual mode

- Feeder characteristics (assignable for each service area)
  - Average speed
  - Route spacing (for fixed route grid)
  - Headway (for fixed route grid)
  - Wait time (for demand responsive systems)
  - Fleet size
  - Transfer time

- Feeder service level
  - Peak
  - Mid-day
  - Evening

- Submodal split
  - Percent walking
  - Percent using mass transit feeder
  - Percent using private automobile

- Demand characteristics
  - Magnitude
  - Service region area
  - Zone/station distance
  - Walk access distance

On vehicle, off vehicle, and total travel times will be modeled for each submode as well as the average of the submodes. These travel times will be modeled for each service interval and for the set of all service intervals (i.e., the entire time modeled); this will be done for each station and for the entire system.

2.1.6 Utilization Modeling Function

This function is used for major processing Step 6 and models utilization for both fixed route and demand responsive service. The FSM utilization modeling function will generate the following utilization measures:

- Feeder vehicle mileage
- Feeder vehicle operating time
- Fleet size

Operating fleet sizes will be computed for each service region for each service interval. The operating fleet size will be the maximum of the sums of regional fleet sizes for each interval.

Operating fleet size for fixed route regions will be modeled as a function of:

- Route mileage
- Feeder average speed
- Headway

Demand responsive regional operating fleet size will be modeled as a function of:

- Feeder average speed
- Wait time
- Service region area
- Service region demand

System fleet size will be modeled as a function of the operating fleet size and a reliability factor which models the effect of having a portion of the fleet out of service for repairs.

The regional vehicle operating time for a service interval will be modeled as the product of the regional operating fleet size and the service interval length. The total regional vehicle operating time will be the sum of the regional interval vehicle operating times; the total system vehicle operating time will be the sum of the total regional times. Similarly, the regional vehicle operating mileage for a service interval will be modeled as the product of regional operating time for the service interval and the average feeder speed, the total regional mileage will be the sum of the regional interval mileages, and the total system mileage will be the sum of the total regional mileages.

2.2 Input Parameters

The following input data is required for the FSM: OD Zone Pair Demand Data; Zone Data; OD Station Pair Performance Data; Station Location Data; Feeder Performance Scale Factors; Performance Modeling Data; Utilization Modeling Data; Submodal Split Data; Intermediate Process Step Data; and Run Control Data.

2.2.1 OD Zone Pair Demand Data

The OD zone pair demand data specifies the transit demand as a level, which is applicable at the start of the time interval for each of a series of intervals, for every OD zone pair in the service area. Thus, zones A and B have demand specified for OD zone pair (A,B) where A is the origin and for (B,A) where B is the origin. It is this data which is mapped onto the network as station/station demand.

2.2.2 Zone Data

The zone data defines:

- the location of the zone centroid as an (X,Y) coordinate
- zone area
- zone/service region assignment

2.2.3 OD Station Pair Performance Data

The OD station pair performance data specifies the value of the performance measure for each OD station pair in the AGT system. This data is needed to determine zone pair trip performance so that zone/station assignments can be made for each zone pair demand.

2.2.4 Station Location Data

The station location data defines the location of each station as an (X,Y) coordinate. This data is used in conjunction with the zone centroid location data to determine the performance of the zone/station portion of a zone/zone trip.

2.2.5 Feeder Performance Scale Factors

The feeder performance scale factors include:

- Exclusive feeder performance scale factor - this factor converts X, Y distance to time for trips made exclusively by feeder.
- Feeder performance scale factor - This factor converts X, Y distance to time for the zone/station portion of trips.
- Feeder comparison scale factor - This factor is the ratio of exclusive feeder service time to feeder/AGT time at which a demand is considered as unserviceable by the AGT system .

2.2.6 Performance Modeling Data

This data includes parameters which affect feeder performance as discussed in Section 2.1.5. The data used for both demand responsive and fixed route service includes:

- Average walk speed
- Average feeder speed
- Average auto speed
- Auto access time
- Acceptable walking distance
- Feeder bus transfer time
- Feeder wait time

2.2.7 Utilization Modeling Data

This data includes the following utilization modeling parameters:

- Fixed route system route mileage
- Fixed route system headway
- Demand responsive wait time
- Reliability Factor

2.2.8 Submodal Split Data

This data defines the criteria for mode assignment by the submodal split function described in Section 2.1.4 and includes:

- Walk mode factor which is the fraction of people which will walk to an AGT system if it is sufficiently convenient.
- Walk area around station
- Zonal walk proportion factor for zone/station pair
- Feeder mode factor which is the fraction of non-walking demand which will use the feeder mode if it is convenient
- Maximum acceptable walking distance
- Effective route spacing
- Actual availability measure
  (headway for fixed route,
  wait time for demand responsive)
- Maximum tolerable availability measure

2.2.9 Intermediate Process Step Data

Major processing steps were identified in Section 2.1. Checkpoint data can be taken during these steps and used with new data in subsequent steps to define new systems; this saves repeating the processing done prior to the checkpoint. For example, major processing Step 1 (see Section 2.1.1) generates preliminary zone/station association data which associates N stations with each zone. The only system definition data required for this step are the zone centroid and station location data. Thus, checkpoint data can be used with a variety of station pair performance definitions, feeder system characteristics, service types, submodal splits, and equipment reliabilities.

2.2.10 Run Control Data

These data define the FSM run to be executed and include:

- N — number of stations to be associated with each zone during the preliminary zone/station association
- Checkpoints — Occurrence of checkpoints to be taken
- Exit point — Processing step after which processing is to terminate (an exit point other than the end of the program normally implies that the run is to collect checkpoint data)
- Entry — Processing step at which processing is to commence (an entry point other than the beginning implies that processing is to start at a checkpoint)

2.3 Outputs

The following outputs will be provided by the FSM.

2.3.1 OD Station Demand Rate Data

The OD station demand data consists of a set of demand matrices specifying demand rate for all OD station pairs. Each matrix is applicable for a particular time interval.

2.3.2 Station Feeder Performance Data

The station feeder performance data includes the access and egress time for each station for each time interval. The average of all three access modes are output in two components: in vehicle and out of vehicle time.

2.3.3 Feeder Utilization Data

The utilization data define the regional and total mass transit vehicle mileage, the total mass transit vehicle operating hours, and the fleet size.

2.3.4 Submodal Split Data

The submodal split data defines the split between feeder, automobile, and walk modes for each service area and for the system.

2.3.5 Station Egress Data

The station egress data defines station egress demand for each station for each time interval.

2.3.6 Unserviceable Demand Data

The unserviceable demand data are the identity and total of demand which is better serviced by pure feeder service than by feeder/AGT service.

2.4 Equipment

The following data are estimates of the hardware and software required to support the FSM. The estimates do not represent requirements but, rather, are intended as broad guidelines for planning purposes.

2.4.1 Hardware

The following computing system hardware is required to support the FSM.

- Central Processing Unit—IBM System 370 Model 145, 148, 155, 158, 165, or 168 capability is required.

- High Speed Random Access Storage — Approximately 150K bytes are required for the FSM itself, including 50K for program storage and 100K for data storage and scratch pad work area. Additional storage is required for the operating system and the required compilers and language translators.

- Direct Access Storage
  - — Program development libraries: 600 K bytes
  - — Input from data base: 150 K bytes
  - — Structured data file: 100 K bytes
  - — Checkpoint files: 8 K bytes

- Magnetic Tape — Magnetic tape will be considered because of the large quantity of input OD zone pair demand data and because some of the OD zone data will be obtained on magnetic tape from outside sources. Nine track tape is assumed.

- Card Reader — A card reader will be required.

- High Speed Line Printer — A high speed line printer will be required for hardcopy output.

2.4.2 Software

The following software is necessary for support and/or use of the FSM:

- System Control Program — Use of one of the following will be assumed:
  - OS/360 (Operating System)
  - VS1 (Virtual Storage 1)
  - VS2 (Virtual Storage 2)
  - VM/370 and CMS (Virtual Machine and Conversational Monitor System)

  For terminal-oriented operation, the use of the Time Sharing Option (TSO) or VM/370 will be assumed.

- Compilers — A FORTRAN (H) compiler is necessary for development, use, and maintenance of the FSM. A PL/I Optimizing compiler is necessary for development (for use in translating structured FORTRAN to standard FORTRAN) and for program maintenance.

- Link Editors — Any link editor compatible with the selected operating system and the aforementioned compilers is sufficient.

- Utilities — Standard Operating System 360/370 utilities will be assumed for development, use, and maintenance of the FSM and will be used for bulk card-to-disk, tape-to-tape, tape-to-disk, dataset backup/restore and data base update and editing.

2.5 Model Interfaces

The FSM indirectly interfaces with other models. Subsets of the FSM OD Station Trip Data are passed via the data base to other AGT-SOS models. The discrete trip demand rate and performance data will be used by the Discrete Event Simulation Model (DESM) and the System Planning Model (SPM). The aggregated utilization measure data will be used by the Cost Model.

The FSM will use network definitions generated with the Network Building Module. It will also use demand data and other parameters placed in the data base with the data base

utilities. One particular use of the FSM is the network tuning analysis loop in which the FSM generates station/station demand input data for the SPM. The SPM outputs link loading data which is used by the analyst to tune the network. The analyst then uses the NBM to update the network. The new network is input to the FSM and the cycle is repeated until the network is sufficiently tuned.

2.6 User Interfaces

The user will use job control commands for the applicable computing system to interface with the FSM. The job control commands will identify the data set path names and source (disc or tape unit) for the FSM inputs and outputs identified in Sections 2.2 (Input Parameters) and 2.3 (Outputs). The user interfaces indirectly with the FSM by utilizing the data base software and system utilities to generate FSM input data sets in the data base and to operate on the output data sets for analytic purposes.

3.0 MODELING TECHNIQUE

3.1 FSM General Structure

The general FSM structure is shown in Figure 1. The input processor will access and check data from the data base for reasonableness, completeness, and compatibility. It will also process input variables and data base overrides in order to generate structured data files for use by the model processor.

The model processor will use analytical equations to compute attribute values for various zone/station assignments. It will then compare values and select the best combinations. Analytical equations will then be used to compute feeder performance as a function of system attribute values and characteristics. The model processor will be able to input or output checkpoint data at major processing steps.

The output processor will generate hardcopy reports and allow online inspection of feeder data. It will also generate performance summary files.

3.2 Feeder System Representation

The FSM models the feeder system as having physical "service regions" characterized by service type and service level. The FSM models three service levels: peak, midday, and evening. Service levels are distinguished by service type characteristics (see Section 2.1.5). Other facets of feeder representation are described in the Functions Section (see Section 2.1).

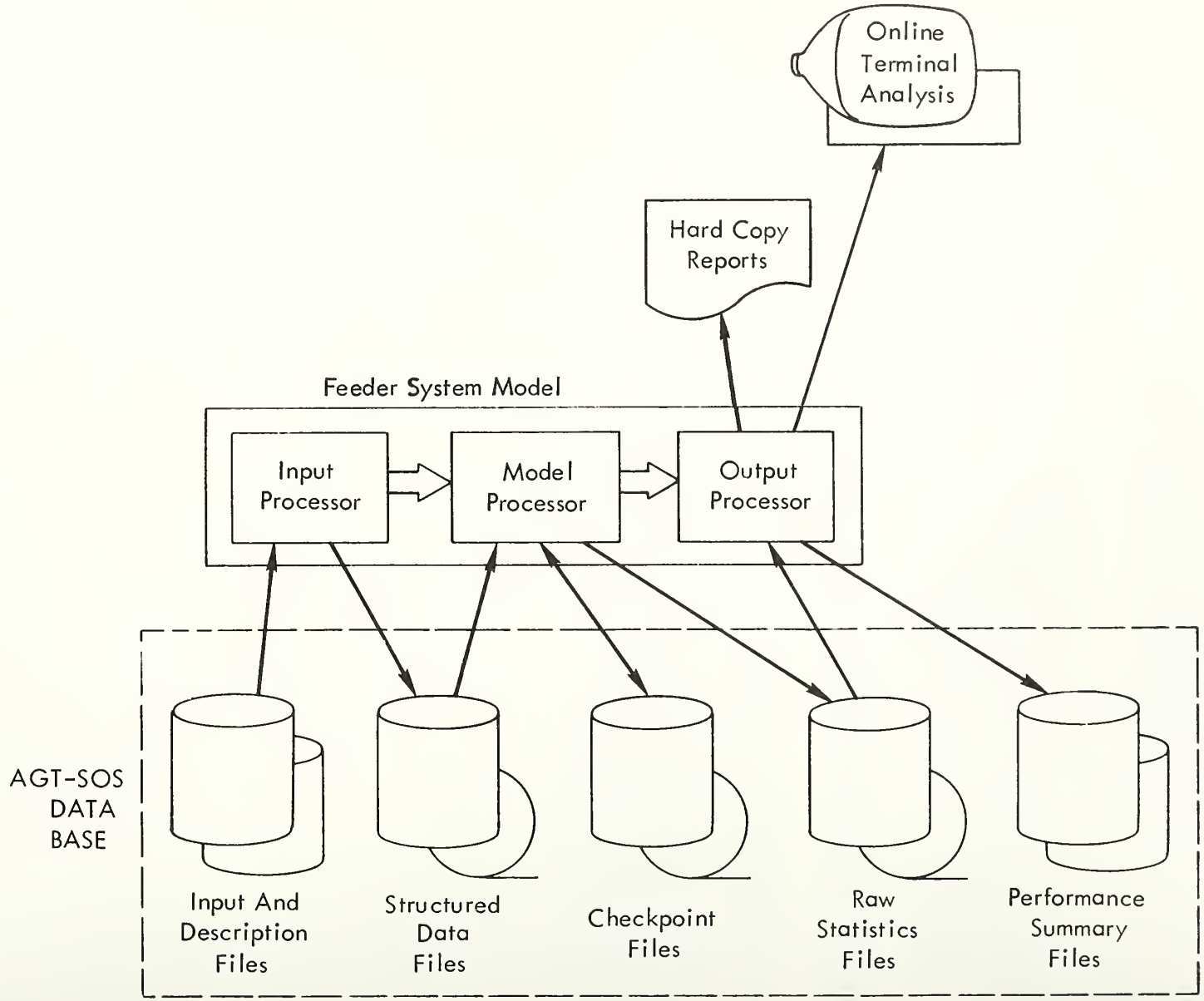

FIGURE 1 FEEDER SYSTEM MODEL STRUCTURE

4.0 HIPO DIAGRAMS

Figure 2 represents a visual table of contents, and Figures 3 through 10 are HIPO diagrams constituting the initial design package for the FSM.

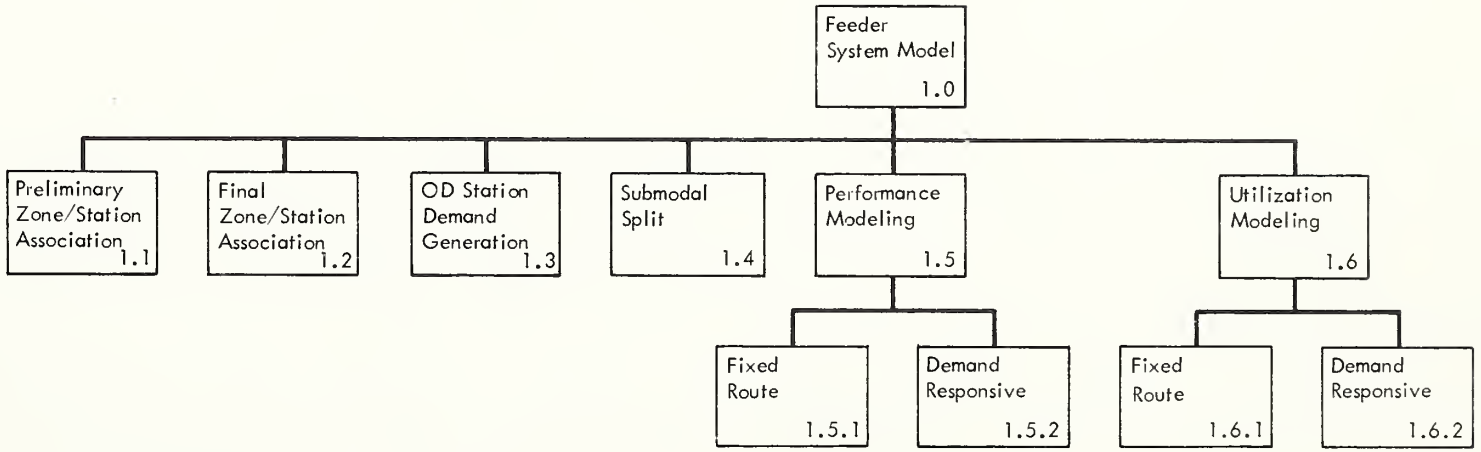

FIGURE 2 HIPO VISUAL TABLE OF CONTENTS

1.1 Preliminary Zone/Station Association

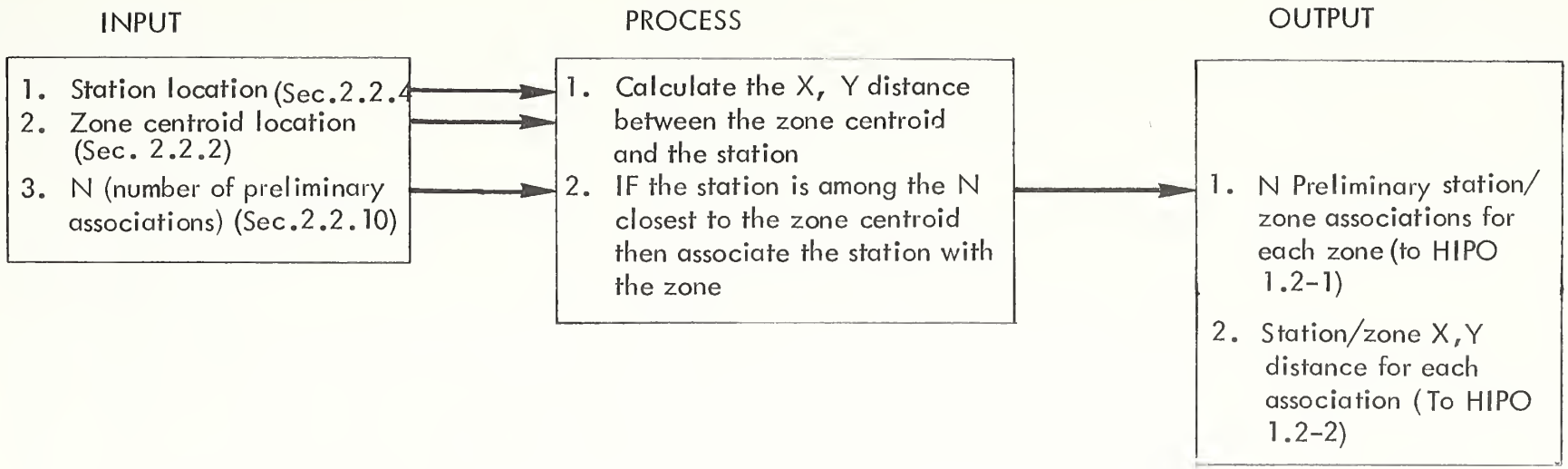
INPUT
1. Station location (Sec.2.2.4
2. Zone centroid location (Sec. 2.2.2)
3. N (number of preliminary associations) (Sec.2.2.10)
PROCESS
1. Calculate the X, Y distance between the zone centroid and the station
2. IF the station is among the N closest to the zone centroid then associate the station with the zone
OUTPUT
1. N Preliminary station/zone associations for each zone (to HIPO 1.2-1)
2. Station/zone X,Y distance for each association (To HIPO 1.2-2)

FIGURE 3 PRELIMINARY ZONE/STATION ASSOCIATION

1.2 Final Zone/Station Association

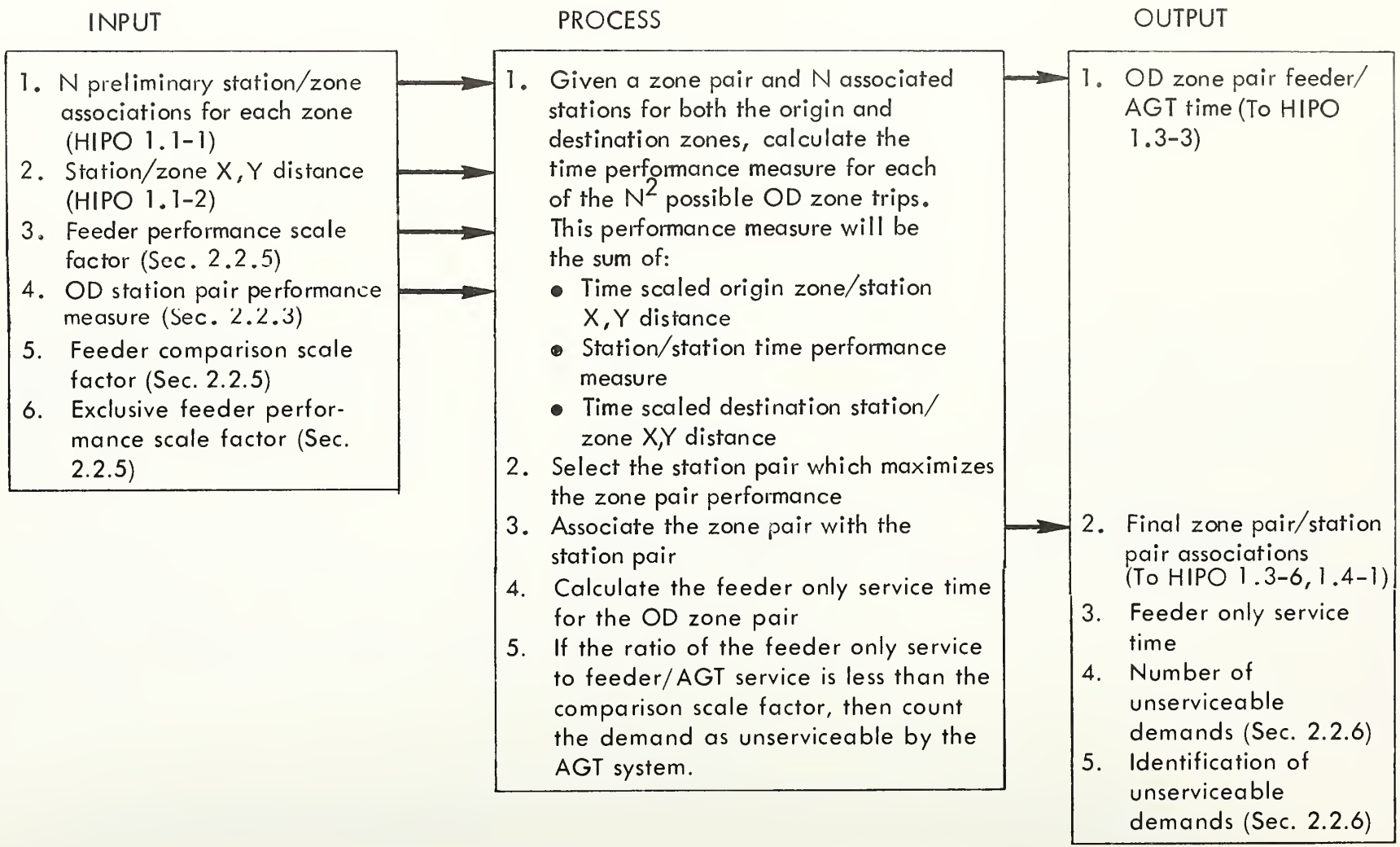
INPUT
1. N preliminary station/zone associations for each zone (HIPO 1.1-1)
2. Station/zone X,Y distance (HIPO 1.1-2)
3. Feeder performance scale factor (Sec. 2.2.5)
4. OD station pair performance measure (Sec. 2.2.3)
5. Feeder comparison scale factor (Sec. 2.2.5)
6. Exclusive feeder performance scale factor (Sec. 2.2.5)
PROCESS
1. Given a zone pair and N associated stations for both the origin and destination zones, calculate the time performance measure for each of the N^2 possible OD zone trips. This performance measure will be the sum of:
• Time scaled origin zone/station X,Y distance
• Station/station time performance measure
• Time scaled destination station/zone X,Y distance
2. Select the station pair which maximizes the zone pair performance
3. Associate the zone pair with the station pair
4. Calculate the feeder only service time for the OD zone pair
5. If the ratio of the feeder only service to feeder/AGT service is less than the comparison scale factor, then count the demand as unserviceable by the AGT system.
OUTPUT
1. OD zone pair feeder/AGT time (To HIPO 1.3-3)
2. Final zone pair/station pair associations (To HIPO 1.3-6, 1.4-1)
3. Feeder only service time
4. Number of unserviceable demands (Sec. 2.2.6)
5. Identification of unserviceable demands (Sec. 2.2.6)

FIGURE 4 FINAL ZONE/STATION ASSOCIATION

1.3 OD Station Demand Generation

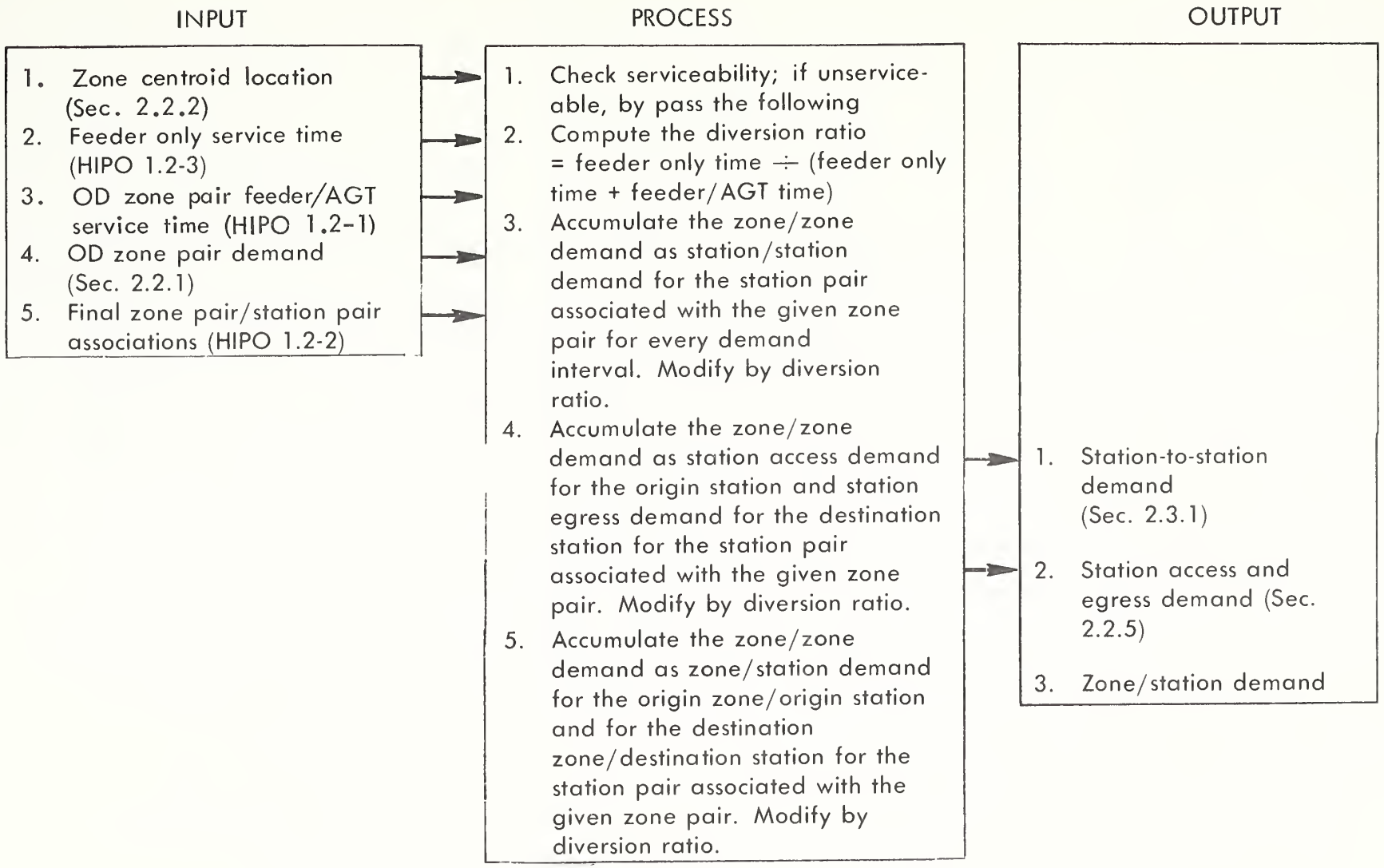
INPUT
1. Zone centroid location (Sec. 2.2.2)
2. Feeder only service time (HIPO 1.2-3)
3. OD zone pair feeder/AGT service time (HIPO 1.2-1)
4. OD zone pair demand (Sec. 2.2.1)
5. Final zone pair/station pair associations (HIPO 1.2-2)
PROCESS
1. Check serviceability; if unserviceable, by pass the following
2. Compute the diversion ratio = feeder only time ÷ (feeder only time + feeder/AGT time)
3. Accumulate the zone/zone demand as station/station demand for the station pair associated with the given zone pair for every demand interval. Modify by diversion ratio.
4. Accumulate the zone/zone demand as station access demand for the origin station and station egress demand for the destination station for the station pair associated with the given zone pair. Modify by diversion ratio.
5. Accumulate the zone/zone demand as zone/station demand for the origin zone/origin station and for the destination zone/destination station for the station pair associated with the given zone pair. Modify by diversion ratio.
OUTPUT
1. Station-to-station demand (Sec. 2.3.1)
2. Station access and egress demand (Sec. 2.2.5)
3. Zone/station demand

FIGURE 5 OD STATION DEMAND GENERATION

1.4 Submodal Split

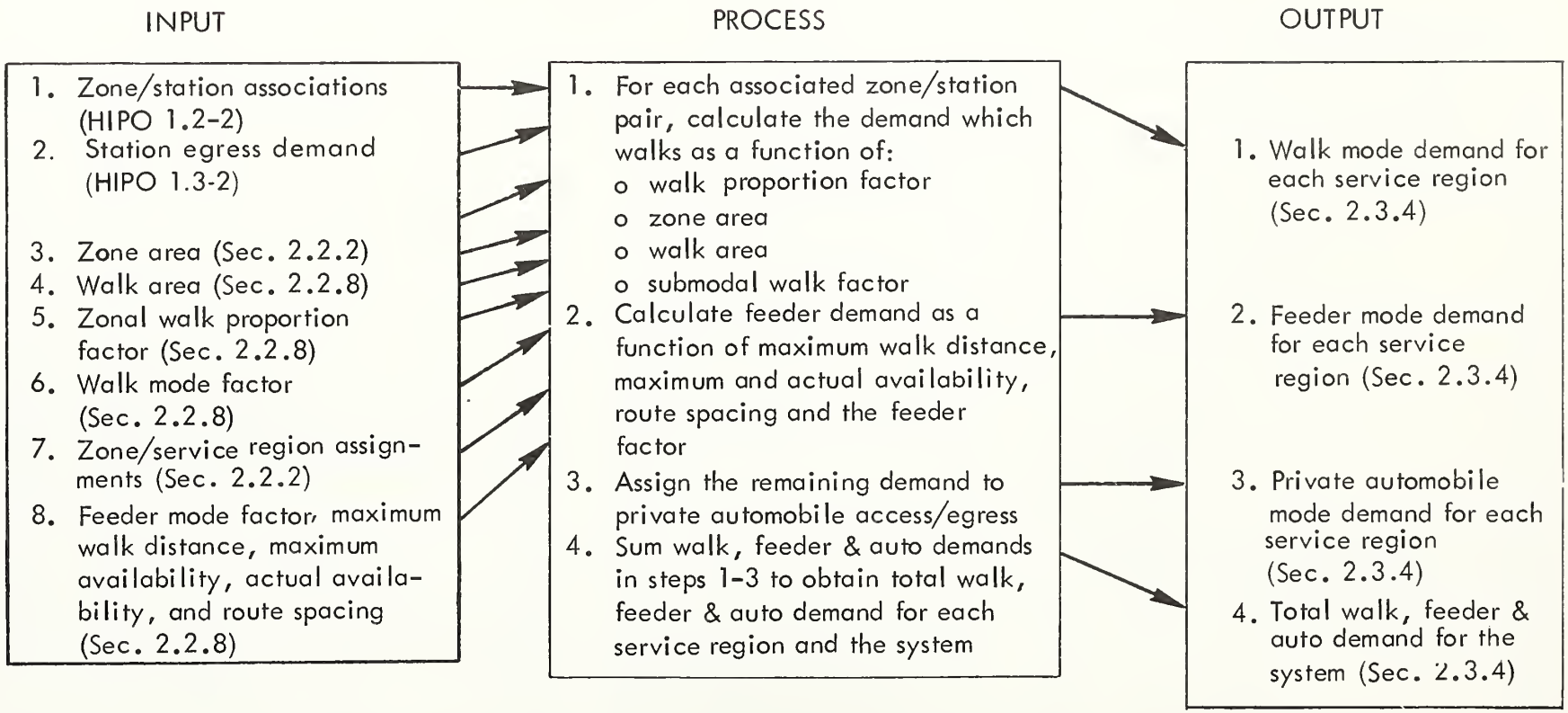
INPUT
1. Zone/station associations (HIPO 1.2-2)
2. Station egress demand (HIPO 1.3-2)
3. Zone area (Sec. 2.2.2)
4. Walk area (Sec. 2.2.8)
5. Zonal walk proportion factor (Sec. 2.2.8)
6. Walk mode factor (Sec. 2.2.8)
7. Zone/service region assignments (Sec. 2.2.2)
8. Feeder mode factor, maximum walk distance, maximum availability, actual availability, and route spacing (Sec. 2.2.8)
PROCESS
1. For each associated zone/station pair, calculate the demand which walks as a function of:
o walk proportion factor
o zone area
o walk area
o submodal walk factor
2. Calculate feeder demand as a function of maximum walk distance, maximum and actual availability, route spacing and the feeder factor
3. Assign the remaining demand to private automobile access/egress
4. Sum walk, feeder & auto demands in steps 1-3 to obtain total walk, feeder & auto demand for each service region and the system
OUTPUT
1. Walk mode demand for each service region (Sec. 2.3.4)
2. Feeder mode demand for each service region (Sec. 2.3.4)
3. Private automobile mode demand for each service region (Sec. 2.3.4)
4. Total walk, feeder & auto demand for the system (Sec. 2.3.4)

FIGURE 6 SUBMODAL SPLIT

1.5.1 Performance Modeling—Fixed Route

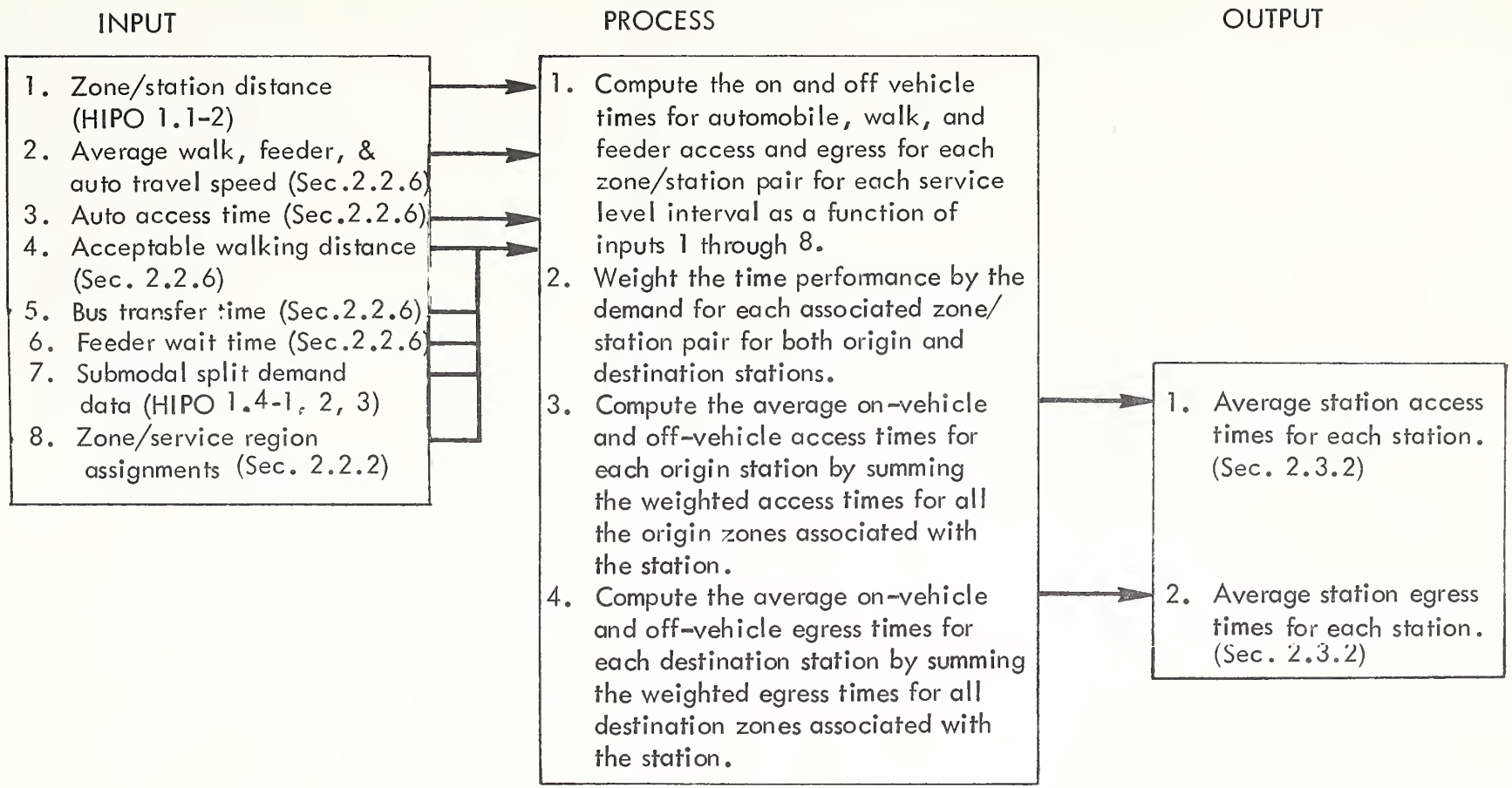
INPUT
1. Zone/station distance (HIPO 1.1-2)
2. Average walk, feeder, & auto travel speed (Sec.2.2.6)
3. Auto access time (Sec.2.2.6)
4. Acceptable walking distance (Sec. 2.2.6)
5. Bus transfer time (Sec.2.2.6)
6. Feeder wait time (Sec.2.2.6)
7. Submodal split demand data (HIPO 1.4-1, 2, 3)
8. Zone/service region assignments (Sec. 2.2.2)
PROCESS
1. Compute the on and off vehicle times for automobile, walk, and feeder access and egress for each zone/station pair for each service level interval as a function of inputs 1 through 8.
2. Weight the time performance by the demand for each associated zone/station pair for both origin and destination stations.
3. Compute the average on-vehicle and off-vehicle access times for each origin station by summing the weighted access times for all the origin zones associated with the station.
4. Compute the average on-vehicle and off-vehicle egress times for each destination station by summing the weighted egress times for all destination zones associated with the station.
OUTPUT
1. Average station access times for each station. (Sec. 2.3.2)
2. Average station egress times for each station. (Sec. 2.3.2)

FIGURE 7 PERFORMANCE MODELING—FIXED ROUTE

1.5.2 Performance Modeling—Demand Responsive

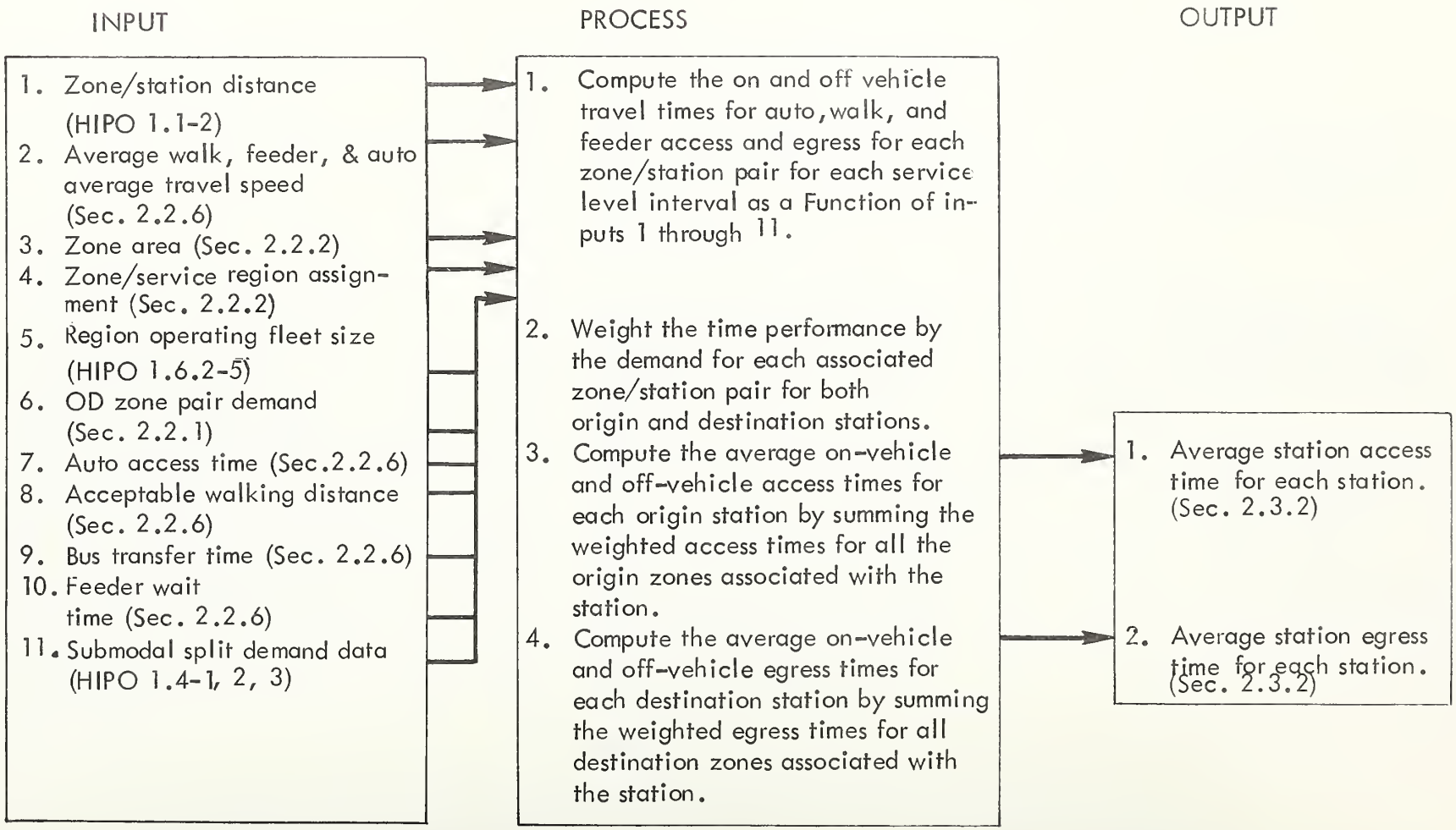
INPUT
1. Zone/station distance (HIPO 1.1-2)
2. Average walk, feeder, & auto average travel speed (Sec. 2.2.6)
3. Zone area (Sec. 2.2.2)
4. Zone/service region assignment (Sec. 2.2.2)
5. Region operating fleet size (HIPO 1.6.2-5)
6. OD zone pair demand (Sec. 2.2.1)
7. Auto access time (Sec.2.2.6)
8. Acceptable walking distance (Sec. 2.2.6)
9. Bus transfer time (Sec. 2.2.6)
10. Feeder wait time (Sec. 2.2.6)
11. Submodal split demand data (HIPO 1.4-1, 2, 3)
PROCESS
1. Compute the on and off vehicle travel times for auto, walk, and feeder access and egress for each zone/station pair for each service level interval as a Function of inputs 1 through 11.
2. Weight the time performance by the demand for each associated zone/station pair for both origin and destination stations.
3. Compute the average on-vehicle and off-vehicle access times for each origin station by summing the weighted access times for all the origin zones associated with the station.
4. Compute the average on-vehicle and off-vehicle egress times for each destination station by summing the weighted egress times for all destination zones associated with the station.
OUTPUT
1. Average station access time for each station. (Sec. 2.3.2)
2. Average station egress time for each station. (Sec. 2.3.2)

FIGURE 8 PERFORMANCE MODELING—DEMAND RESPONSIVE

1.6.1 Utilization Modeling-Fixed Route

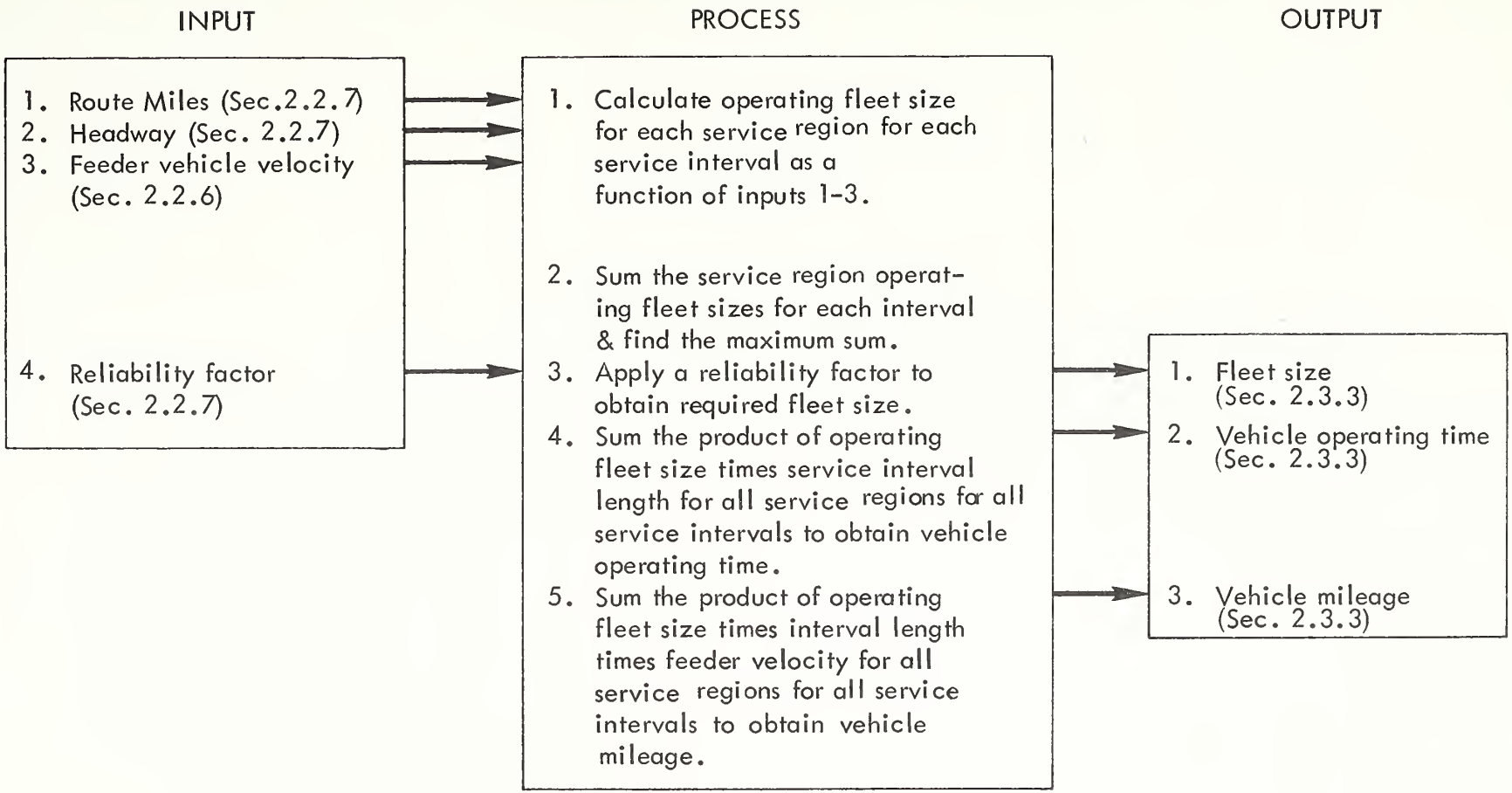
INPUT
PROCESS
OUTPUT
1. Route Miles (Sec.2.2.7)
2. Headway (Sec. 2.2.7)
3. Feeder vehicle velocity (Sec. 2.2.6)
4. Reliability factor (Sec. 2.2.7)
1. Calculate operating fleet size for each service region for each service interval as a function of inputs 1-3.
2. Sum the service region operating fleet sizes for each interval & find the maximum sum.
3. Apply a reliability factor to obtain required fleet size.
4. Sum the product of operating fleet size times service interval length for all service regions for all service intervals to obtain vehicle operating time.
5. Sum the product of operating fleet size times interval length times feeder velocity for all service regions for all service intervals to obtain vehicle mileage.
1. Fleet size (Sec. 2.3.3)
2. Vehicle operating time (Sec. 2.3.3)
3. Vehicle mileage (Sec. 2.3.3)

FIGURE 9 UTILIZATION MODELING-FIXED ROUTE

1.6.2 Utilization Modeling-Demand Responsive

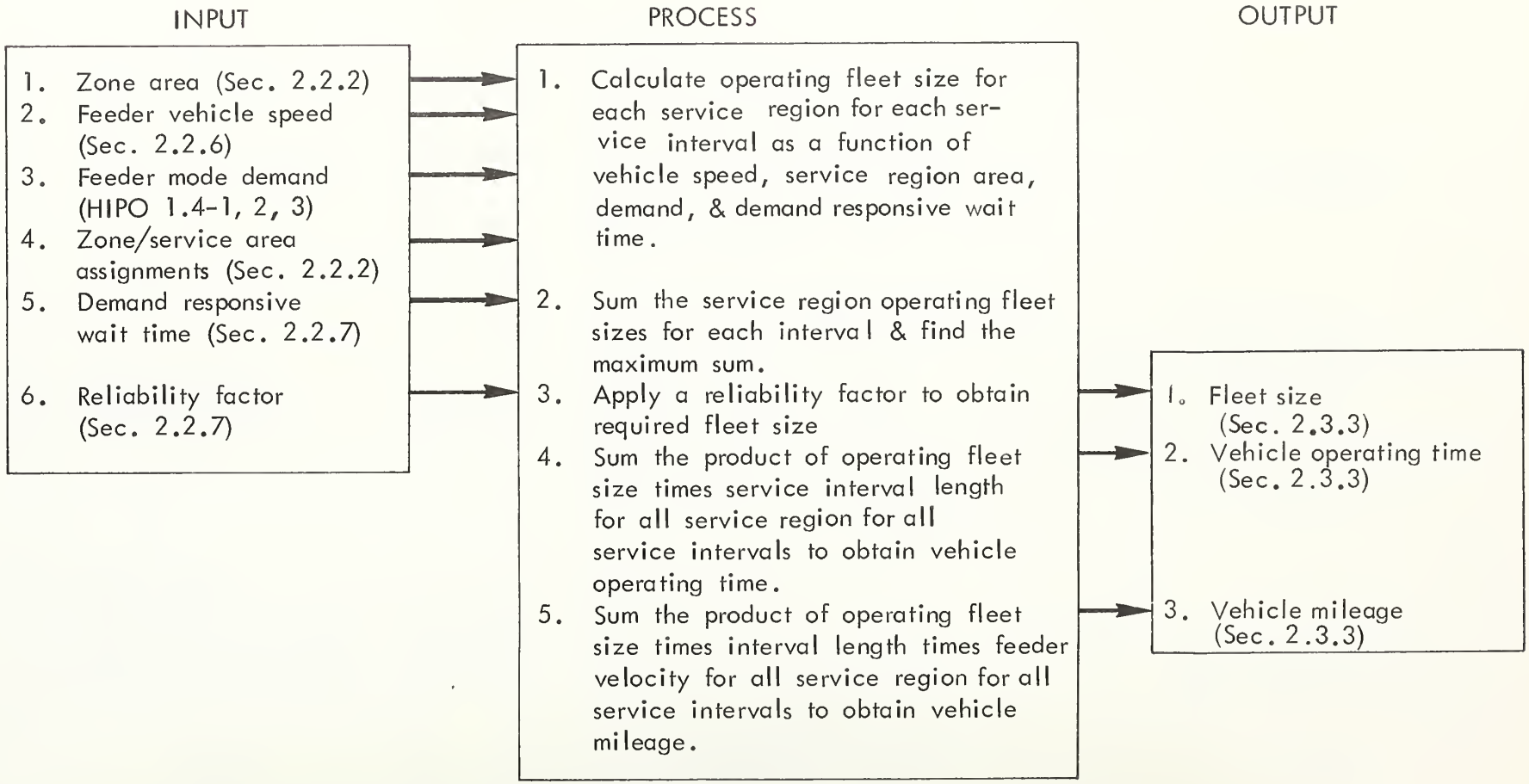
INPUT
1. Zone area (Sec. 2.2.2)
2. Feeder vehicle speed (Sec. 2.2.6)
3. Feeder mode demand (HIPO 1.4-1, 2, 3)
4. Zone/service area assignments (Sec. 2.2.2)
5. Demand responsive wait time (Sec. 2.2.7)
6. Reliability factor (Sec. 2.2.7)
PROCESS
1. Calculate operating fleet size for each service region for each service interval as a function of vehicle speed, service region area, demand, & demand responsive wait time.
2. Sum the service region operating fleet sizes for each interval & find the maximum sum.
3. Apply a reliability factor to obtain required fleet size
4. Sum the product of operating fleet size times service interval length for all service region for all service intervals to obtain vehicle operating time.
5. Sum the product of operating fleet size times interval length times feeder velocity for all service region for all service intervals to obtain vehicle mileage.
OUTPUT
1. Fleet size (Sec. 2.3.3)
2. Vehicle operating time (Sec. 2.3.3)
3. Vehicle mileage (Sec. 2.3.3)

FIGURE 10 UTILIZATION MODELING-DEMAND RESPONSIVE

5.0 VERIFICATION

The FSM verification procedure will verify that the software mechanization of the FSM model performs all functions as described in the technical specification. Formal verification procedures will be developed and executed for each FSM feature. In general, the features of the FSM will be verified by comparing FSM results with hand-calculated results for several feeder configurations. This will be done for both demand responsive and fixed route service and for all discrete service levels.

6.0 VALIDATION

FSM validation will be controlled by a procedure designed to demonstrate that the verified model provides a valid representation of the real world entity or state of affairs it is modeling. The validation process will provide assurance to transportation planners that the conclusions reached and data generated by these studies are realistic and can be used with reasonable confidence. In addition, one of the overall goals for validation is that test cases be sought such that at least one case exercises each model feature and that the number of such test cases be the economical minimum that will serve this purpose.

FSM validation will comprise three steps:

1. Establishing specific criteria for the validation within the framework of the overall validation goals. What is to be an acceptable degree of correspondence between the model results and the exogenous information being compared will be specified in the validation procedure.

2. Performing the validation by one or more of the following methods.

   - Compare the model's prediction of performance to actual measured performance for an existing system under a set of well-defined test conditions

   - Compare the model's prediction of performance of the system to the results of a previously validated model

   - Compare the model prediction to an estimate of system performance derived by an independent analytical process.

3. And, reporting on how well the validation exercise met the validation goals. For example, should presently unavailable data be needed to more fully validate a certain model feature, then that needed data will be identified. Also, the degree of correspondence between predicted and actual information obtained will be interpreted for acceptability.

In the case of the Feeder System Model, it appears that independent analytical techniques will be necessary to complete the validation process.

APPENDIX

REPORT OF NEW TECHNOLOGY

Work performed by GM Transportation Systems Division under contract DOT-TSC-1220 in the area covered by this report resulted in the development of a new Feeder System Model (FSM) to be used as one of the tools for Automated Guideway Transit (AGT) system deployment analyses. The major function is to generate the AGT station-to-station patronage demand based on the given feeder environment of the study area. The strength of the FSM stems from its simplicity in use and its compatibility with other System Operations Study (SOS) models to perform the AGT system representative deployment analyses. Options may also be elected to adapt empirical demand data or data generated by other models and converting to SOS compatible data for SOS analyses.

This report documents the functional specification of the Feeder System Model.

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